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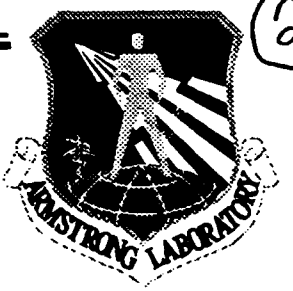

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ARMSTRONG LABORATORY

TESTING AND EVALUATION OF THE PERCUSSIONAIRE CORPORATION MILITARY TRANSPORTER RESPIRATOR, MODEL TXP

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CREW SYSTEMS DIRECTORATE
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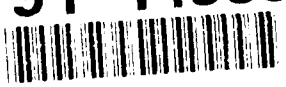
October 1991

Final Report for Period January 1989 – August 1989



AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5000

NOTICES

This report has been reviewed and is approved for publication.

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The U.S. Army Institute of Surgical Research Burn Flight Team at Fort Sam Houston TX has the unique missions of rapid deployment to the scene of burn accidents and transport of burn victims to the nearest burn facility. The Burn Flight Team uses the Military Transporter Respirator, Model TXP, to aid in the rapid transport of burn accident victims requiring ventilatory assistance. The team submitted the respirator to the Armstrong Laboratory's Aeromedical Research Function, located at Brooks AFB Tx, for testing and evaluation for use on aeromedical evacuation aircraft. The Model TXP respirator passed all laboratory and inflight testing, and was found acceptable for use on aeromedical evacuation missions.

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TESTING AND EVALUATION OF THE PERCUSSIONAIRE CORPORATION MILITARY TRANSPORTER RESPIRATOR, MODEL TXP

INTRODUCTION

The United States Army Institute of Surgical Research, Burn Flight Team at Fort Sam Houston, Texas has the unique mission of rapid deployment to the scene of a burn accident and the transport of burn victims to the nearest burn care facility. The Burn Flight Team uses a special respirator and oxygen delivery system to maintain burn victims requiring respiratory assistance. Occasionally, there is a requirement to transport the burn patient, with the respirator and oxygen delivery system, aboard aeromedical evacuation aircraft, operated by the United States Air Force (USAF) Military Airlift Command (MAC). MAC regulation (1) requires that medical equipment items used aboard their aircraft must first be evaluated for acceptability at the Armstrong Laboratory (formerly USAF School of Aerospace Medicine) at Brooks AFB, Texas. At the request of Burn Flight Team, Military Transporter Respirator, Model TXP, manufactured by the Percussionaire Corporation of Sand Point, Idaho was evaluated for use aboard MAC aircraft.

Description

The Military Transporter Respirator Model TXP (hereafter referred to as the TXP) (Fig. 1) is designed as an acute care device to be used with a one-on-one clinical relationship between the patient and health care provider; therefore, qualified medical surveillance must be constantly maintained (2). The respirator does not have the failure alarms normally used on respirators. As a safety feature, the respirator has a vented entrainment port, allowing the patient access to ambient air in the absence of source gas pressure. The respirator is time cycled and is totally pneumatic without electronic circuitry. The respirator has only one control, the ventilation control knob, which determines the ventilation rate, and one indicator, the proximal airway pressure gauge. (The Burn Flight Team uses a portable respirometer, which is not a part of the respirator, to accurately measure the volumetric output.) The respirator will operate in any position and has color-coded tubing and accessories with snap-on/off connectors. Respirator operating features and specifications are listed in Appendix A.

The lightweight therapeutic oxygen cylinder providing the portable oxygen supply for the system is manufactured by Structural Composites Industries (SCI) of Pomona, California, Stock No. ALT-281. The cylinder has a seamless aluminum lining fully reinforced with Kevlar fibers embedded in resin (3). The cylinder is already used in both commercial and military applications in missiles, inflation of aircraft escape slides, and portable crew emergency oxygen systems (Fig. 2) During manual transport of a patient on a litter, the composite cylinder is strapped on the back of medical personnel, using a scuba cylinder harness (Fig. 3). Once the patient is situated inside the vehicle or aircraft, the cylinder is left in the scuba cylinder harness and strapped to a permanent part of the vehicle. Operating features and specifications of the composite oxygen cylinder are listed in Appendix A.

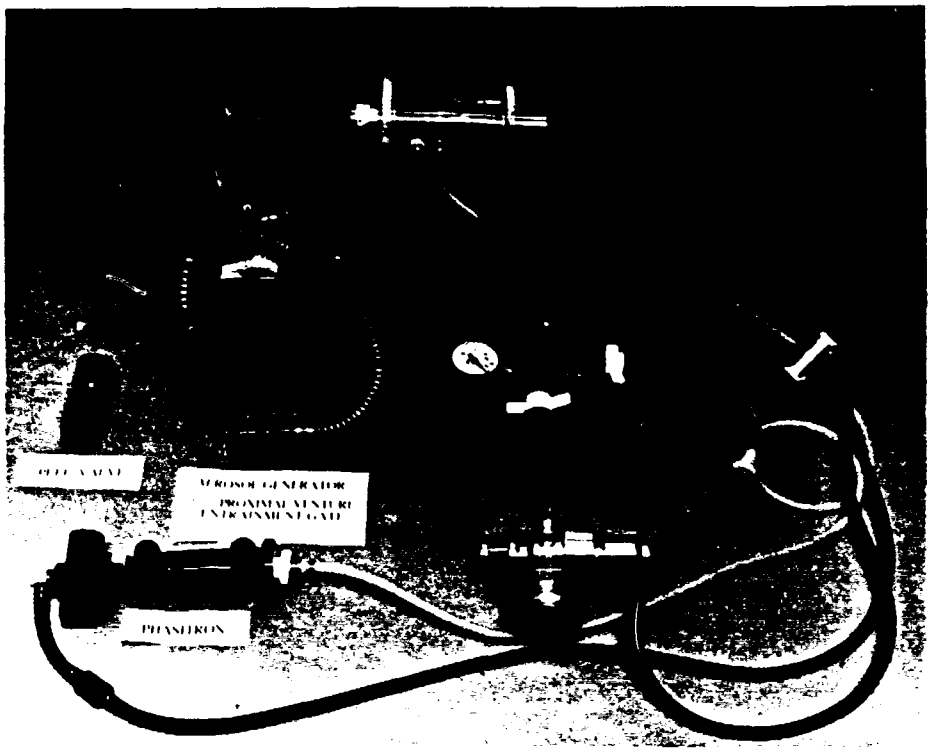

Figure 1. The Military Transporter Respirator, Model TXP, and accessories.

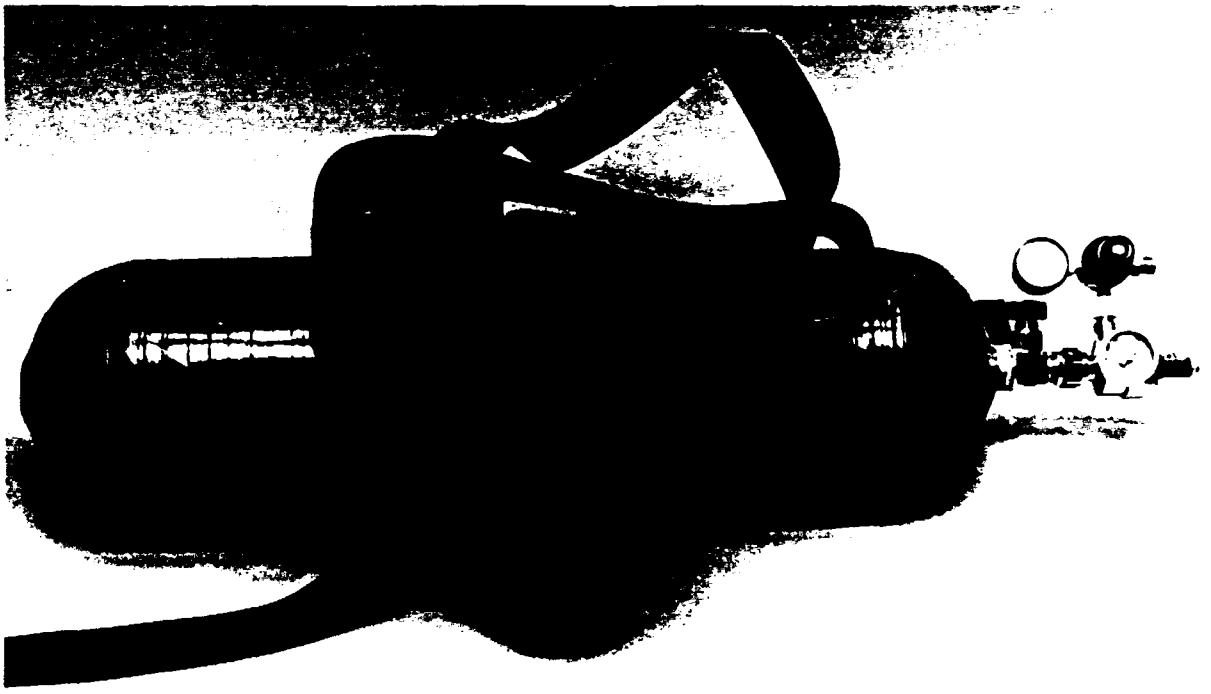

Figure 2. The Structural Composites Industries oxygen cylinder.

Figure 3. The TXP and SCI oxygen cylinder carried by medical personnel.

METHODS

General

The Aeromedical Research Function (ARF) develops test procedures covering safety, human factors, and environmental and engineering issues regarding tested equipment items. This section is derived from the ARF Procedures Guide (4). The section describes which tests are performed, and provides a quantitative description of those tests. Not every piece of equipment we evaluate undergoes each and every

test. Also, since every piece of equipment is different and unique, not every piece of equipment undergoes a test in exactly the same way.

Each device is first subjected to a Baseline Performance Assessment (BPA), which is a test of the operation of the device using directions and procedures described in the operator's manual.

Then various tests which were designed to simulate the environment in which the device must function are performed. We duplicated field or operational conditions as closely as possible. The tests are designed to vary only 1 parameter at a time. Comparison to the BPA enables us to assess each test's effect on the item.

Data is collected by computer whenever possible, simplifying the plotting and analysis of the data. If the computer cannot collect the data, it is manually recorded on a "Data Collection Sheet." Information specifically relating to the test setup is logged on a "Test Information Sheet."

Specific

Test Setup. The respirator was connected to an Adult Lung Analyzer, Model VT-1, manufactured by Bio-Tek. The VT-1 measured and recorded 17 parameters in the "Full Test" mode, and 4 parameters in the "Status Test" mode. The Full Test mode included the following parameters: breath rate, inspiratory-to-expiratory ratio (I:E ratio), tidal volume, minute volume, inspiratory time, inspiratory hold time, expiratory time, expiratory hold time, cycle time, peak airway pressure, peak lung pressure, end expiratory pressure, mean airway pressure, inspiratory flow, expiratory flow, airway pressure (AP) variation, and volume variation. Status test mode included breath rate, tidal volume, minute volume, and I:E ratio.

The respirator and oxygen source pressure were adjusted to deliver approximately 12 breaths per minute, with a tidal volume of 0.6 liters. The oxygen source was either an "H"-sized oxygen cylinder or the composite oxygen cylinder.

The compliance of the VT-1 was set at .05 l/cmH_2O, and airway resistance was set at 20 cmH_2O/l/min, because these settings most closely simulate the lung characteristics of an adult respiratory patient's lungs.

Performance Check. Three Full Tests at ambient conditions (22.0±2 °C, 750±10 mmHg barometric pressure, 50±30% relative humidity) were run at 5-min intervals, before and after each major test condition (i.e., vibration or altitude). The Status Test data was continuously monitored, but not recorded. During each major test, the Full Test was run and all the parameters were recorded every 15 min. Values derived from the 3 pretest recordings were used as baseline references in determining variation percentages recorded during testing.

Post test performance check values were used to identify any deviation from the pretest performance check which might indicate damage to the respirator due to the testing. Recordings were graphed and analyzed using Cricketgraph software.

Although there are several accessories available with the respirator, only the positive end expiratory pressure (PEEP) valve, air entrainment valve, and humidifier accessories were provided by the Burn Flight Team. Since the accessories were provided towards the end of the testing period, only a brief hypobaric chamber test on the PEEP valve and the air entrainment valve was performed.

The respirator, composite oxygen cylinder, and the oxygen regulator are used as a system by the Army Burn Flight Team. However, because of safety concerns and laboratory constraints, we were unable to examine the system as a whole in the vibration, environmental, rapid decompression, and in-flight tests.

Baseline Performance Assessment

The purpose of the BPA was to quantitatively measure and record the respirator's performance under standard ambient conditions before adverse testing. The BPA was used as a reference to measure subsequent performance against and verify manufacturer and contract specifications; and to ensure safe operation before testing. Specifically, the BPA included the following:

Initial Inspection. The initial inspection is an operational verification comparing the respirator's operating characteristics (i.e., ventilation rate, tidal volumes, inspiratory/expiratory ratio) to its numerically displayed parameters. These operating characteristics are measured, recorded, and compared to the manufacturer's published specifications.

Electrical Safety. Normally an important part of the BPA, an electrical safety check was not required, since the respirator contains no electrical parts.

Vibration

These tests were designed to determine an item's construction, durability, and performance during worst case scenario vibrations. The respirator was subjected to vibration tests in accordance with MIL-STD-810D (5). These tests consist of random (11 to 2,000 Hz) and sinusoidal (5 to 500 Hz) curves on X, Y, and Z axes. The vibration table was controlled by an Unholtz-Dicky control panel, operated by technicians from the Armstrong Laboratory Maintenance Services Branch (AL/DOJM). During sinusoidal test, the respirator was operated and vibrated for 5 sweeps of 15-min duration (for a total of 75 min) on each axis. During random tests, the respirator was operated and vibrated for 30 min on each axis. Before and after each axis, a visual examination of the respirator was performed, and VT-1 measurements were recorded.

The TXP and oxygen cylinder had no standard securing devices, other than the harness used to secure to the back of a person; therefore, they were secured to the vibration table using duct tape.

Environmental

Our environmental test conditions were tailored (based on the aeromedical operational environment) versions of those found in the MIL-STD-810D. These tests measured the system's performance under varying temperature and humidity conditions encountered during transport. Only the TXP was inside the environmental chamber. The oxygen cylinder and regulator, and the VT-1 setup were outside the chamber. At the end of each test, the chamber was dehumidified and the temperature was changed to 24.7 °C (75 °F) to return to existing ambient conditions. The respirator remained inside the chamber for 30 min during the post test stabilization period, then post test measurements were taken.

High Temperature: Operation: 49 °C±2 °C (120 °F±3.6 °F) for 2 h.
Storage: 60 °C±2 °C (140 °F±3.6 °F) for 6 h.

Low Temperature: Operation: 0 °C±4 °C (32 °F±7.2 °F) for 2 h.
Storage: -40 °C±2 °C (-40 °F±3.6 °F) for 6 h.

Humidity: Operation: 94±4% relative humidity, 29.5 °C±2 °C (85 °F±3 °F) for 4 h.

Altitude

Three hypobaric chamber "flights" were performed. The standard protocol for the tests was a climb to 10,000 ft (atmospheric pressure of 523 mmHg) at an ascent rate of 1,000 ft per min. The ascent was stopped at 2,000 ft increments to zero the VT-1 transducers and compensate for the change in atmospheric pressure. A full test (with all 17 parameters) measurement was recorded at each 2,000 ft increment. At 10,000 ft, the chamber was stabilized and 3 full tests were recorded at 5-min intervals.

The first flight was to observe the change in operation of the respirator during changing atmospheric pressure. In the second flight, we verified the manufacturer's claim that the respirator will self-compensate for the first 8,000 ft change in altitude and their recommendation to adjust the respirator at higher altitudes. The third flight was to observe the effect of the PEEP and air entrainment valves on the performance of the respirator while at altitude. The PEEP valve value was set at 3.0 cmH_2O.

Rapid Decompression

Decompressions are uncommon; however, if one were to occur, the respirator should not present a hazard to the patient, crew, or aircraft operations. Testing was conducted in the small equipment test chamber, which was controlled by AL. Pre and post tests were done using the VT-1. For operation while inside the chamber, the respirator was attached to a Michigan Instruments Model 1600 mechanical lung analyzer, simulating the patient's lungs. We used this simplified mechanical test lung because of the possibility of damage to the sensitive VT-1. Pressure transducers, to

measure the chamber pressure and the peak airway pressure at the mechanical lung analyzer, were connected to a Gould Series 2000 strip-chart recorder, to log the performance of the respirator during the decompression. With the respirator and test equipment placed inside the sealed chamber, the chamber was depressurized to 8,000 ft equivalent. Over a period of 60 s the chamber was depressurized to 40,000 ft equivalent. The respirator system was observed and allowed to continue to operate for 5 min; then the chamber was returned to ground level. Post tests were done using the VT-1, followed by placing the respirator system back in the chamber. The entire procedure was repeated twice, with the decompressions occurring over periods of 7 and 1 s.

Airborne Feasibility

The purpose of airborne testing was to evaluate the respirator system's compatibility with each of MAC's aeromedical evacuation airframes. Potentially this device could be used to ventilate patients on several of MAC's airframes, including C-9, C-12, C-21, C-130, and C-141 aircraft; and UH-1 and H-60 helicopters. Since the TXP and oxygen cylinder are so small, we decided that an evaluation on the C-9 would be representative of any air evacuation mission. The evaluation was conducted by our charge nurse and an aeromedical research technician, who were both qualified and current on the C-9. The respirator was connected to the Medical Development Ltd Model LS-122 Test Lung. Tidal volume, rate, I:E ratio, and oxygen percentage were recorded at 15 min intervals. Pre and post test measurements were also recorded.

We evaluated the operational capability of the respirator under actual flight conditions, integration with aircraft facilities, on/off loading procedures, securing the respirator on board the aircraft, and other human factors.

Composite Oxygen Cylinder

In-flight use of the SCI oxygen cylinder is governed by the U.S. Department of Transportation (DOT) regulations. Therefore, we did not test the cylinder. Rather, we monitored SCI's petition to the DOT Office of Hazardous Material for approval to use the cylinder as an equipment component aboard aircraft.

RESULTS

Baseline Performance Assessment

During the initial inspection, we observed a linear change in the output of the respirator as we varied the ventilation knob and the oxygen source pressure. Actual use of the respirator will require a manual counting of the ventilation rate and/or the use of a portable respirometer, since the TXP has only a proximal airway pressure gauge to indicate its output.

Vibration

The respirator's rate, measured in breaths per minute (BPM), tidal volume measured in ml, and peak airway pressure measured in cmH_2O, before and during vibration, are illustrated in Figures 4-6. The data show the respirator delivered varying volumes and rates throughout vibration testing. There were instances when deviations during vibration were more than 10% over the previbration values. However, these deviations can be manually compensated for by the attending health care provider. Since the respirator was designed for the acute care environment, constant monitoring of the patient and respirator is essential, including making necessary adjustments to the respirator and oxygen source pressure. These manual adjustments will correct the variations in rate, volume, and pressure.

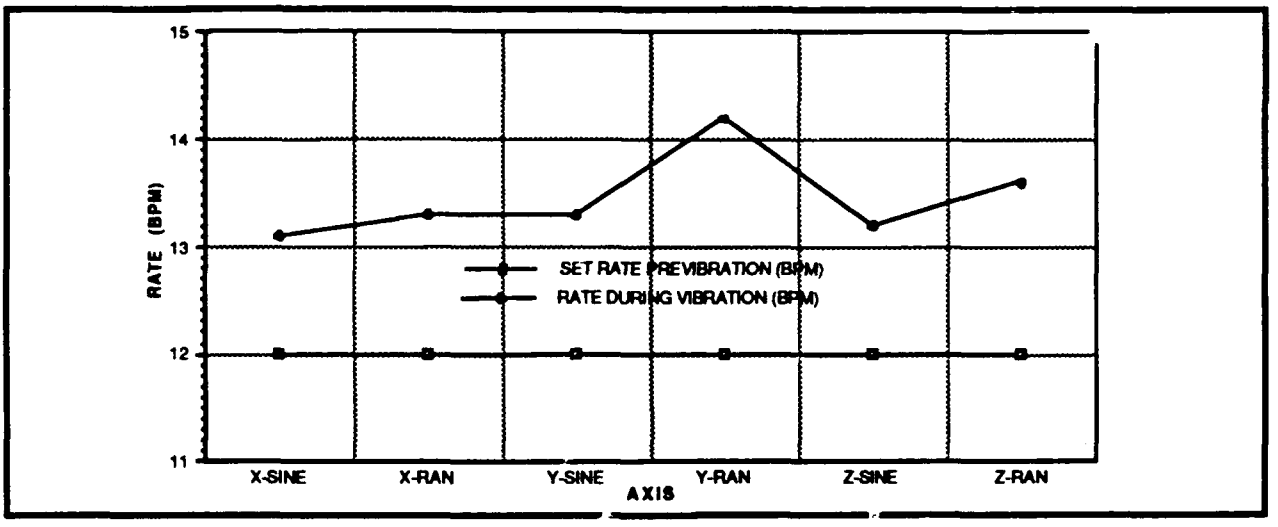

Figure 4. TXP rate before and during vibration testing.

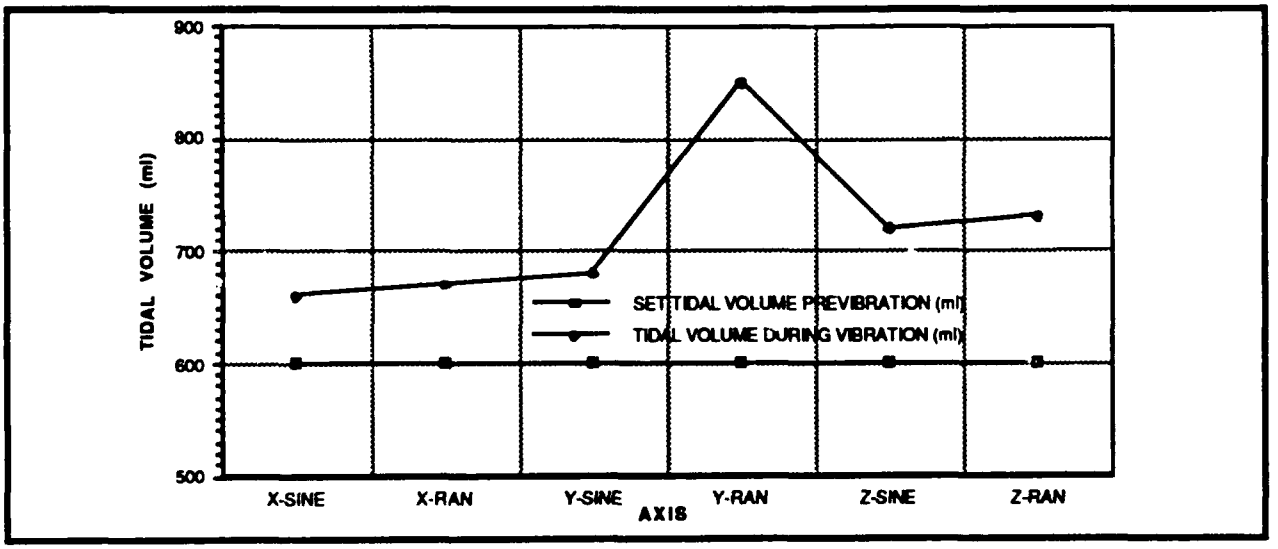

Figure 5. TXP tidal volume before and during vibration testing.

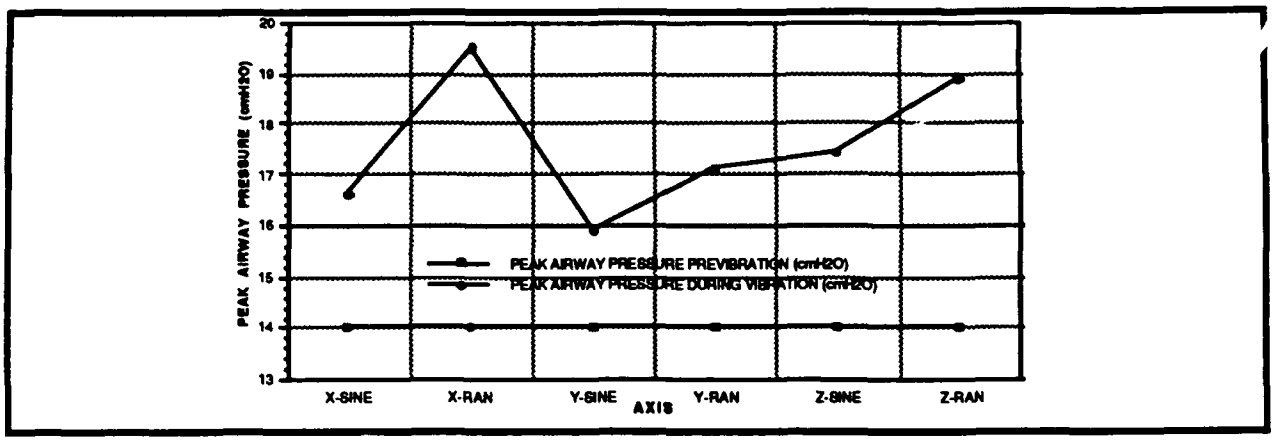

Figure 6. TXP peak airway pressure before and during vibration testing.

Environmental

The respirator operated within 10% of the pretest characteristics during the environmental tests, with the following exceptions: The performance check after hot temperature operation revealed that the respirator increased the delivered tidal volume from 600 ml to 700 ml; peak airway pressure from 18 cmH_2O to 21.3 cmH_2O; and peak lung pressure, from 18 cmH_2O to 21 cmH_2O. Those variations, approximately 18%, are probably insignificant in terms of clinical importance.

Altitude

The respirator responded to the altitude change by increasing the peak airway pressure and tidal volume during ascent; and decreasing both values during descent, as shown in Figures 7 and 8.

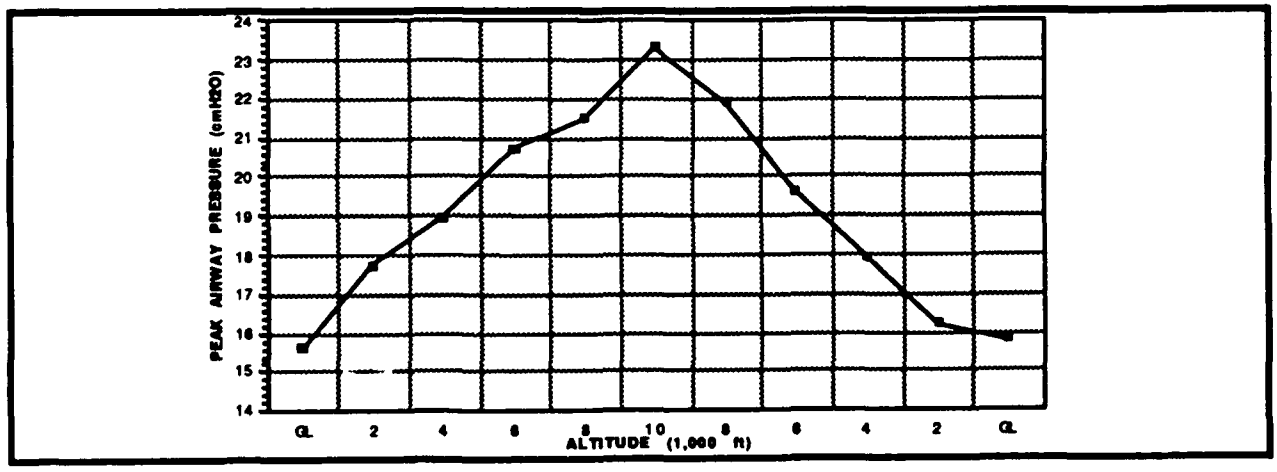

Figure 7. TXP peak airway pressure during altitude testing, with the pressure reading 16 cmH_2O before testing.

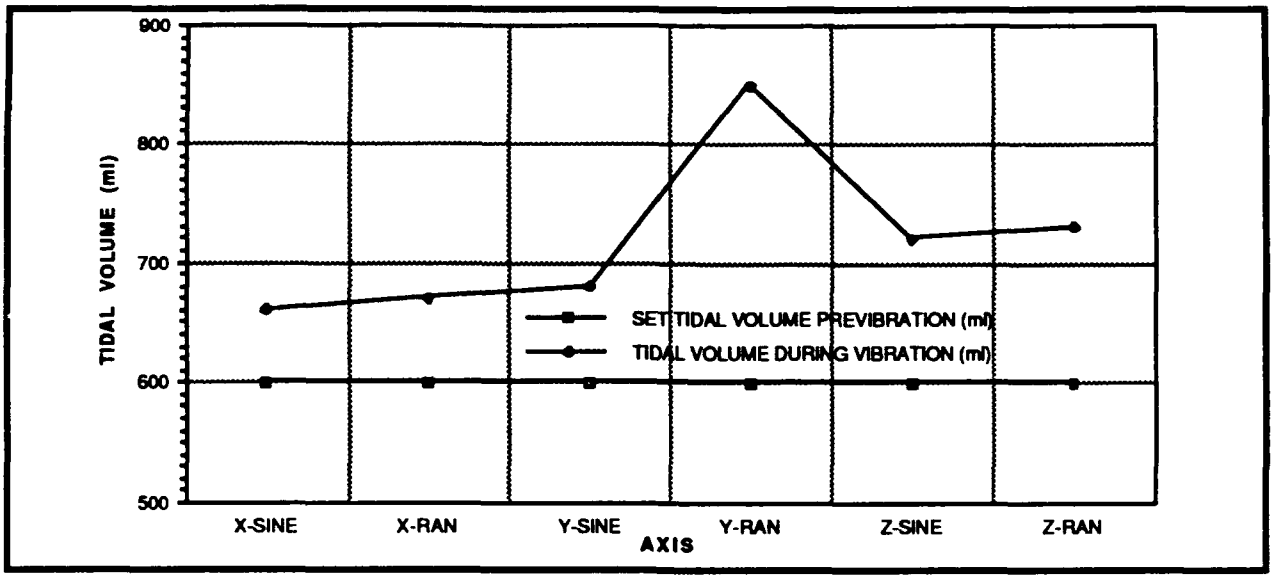

Figure 8. TXP tidal volume during altitude testing, with the tidal volume reading 600 ml before testing.

The respiration rate decreased during ascent and increased during descent (Fig. 9).

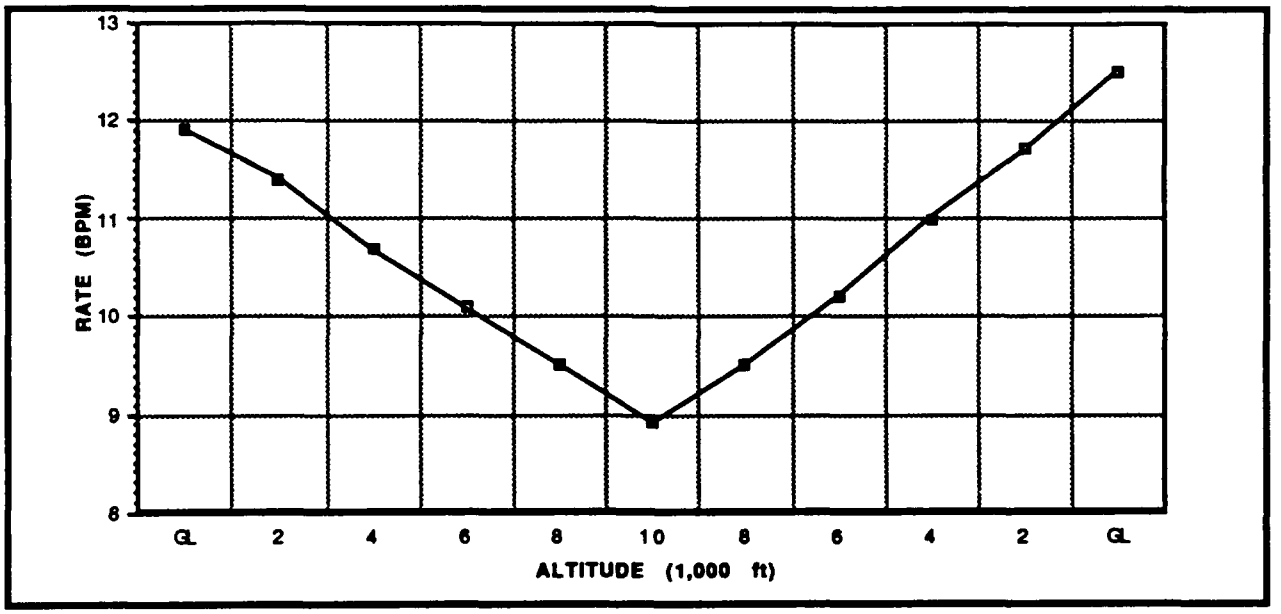

Figure 9. TXP rate during altitude testing, with the rate set at 12 BPM before testing.

The PEEP valve and the air entrainment valve did not change the operational characteristics of the respirator, except for the normal effect of the PEEP valve to hold the end expiratory pressure at a preset value.

As illustrated, the respirator did not automatically compensate for the changes in altitude, as stated by the manufacturer; however, manual compensation could be made.

As mentioned earlier, the respirator is an acute care respirator and the presence of qualified medical personnel to constantly monitor the patient is required. During an aeromedical evacuation flight, this one-on-one care will require an adjustment of the respirator and the oxygen source pressure to deliver respirations at the same pressure, volume, and rate as at ground level.

Rapid Decompression

During the 7-s decompression, the respirator became inoperable, but resumed operation after 17 s. During the 1-s decompression, the respirator also became inoperable, but resumed operation after 19 s. After each decompression, there was a significant increase in peak airway pressure, as shown in Figure 10. Also, there was a significant increase in the expiratory time and change in the inspiratory:expiratory ratio time, as shown in Figure 11.

In spite of those changes during the decompressions, which were expected, the results were not considered as failures. The decompressions did not cause permanent damage to the respirator, and would present no hazard to the patient or attendant. In the unlikely event of a rapid decompression, the respirator would require adjustment by the attendant, and manual ventilation would have to be administered during the period of inoperation.

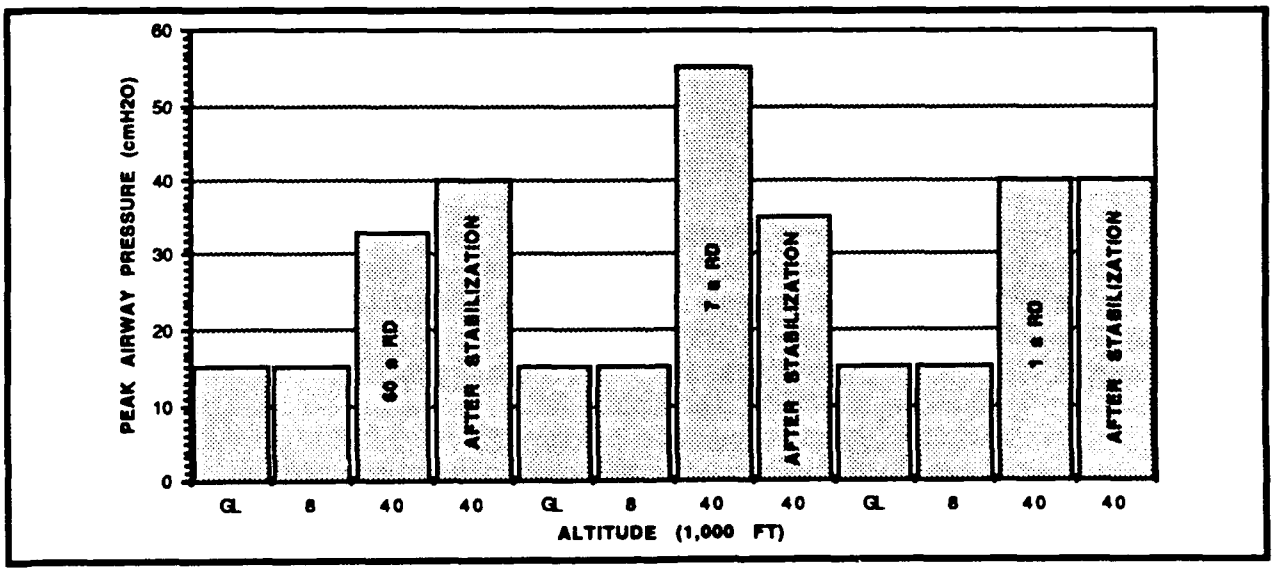

Figure 10. TXP peak airway pressure during rapid decompression testing.

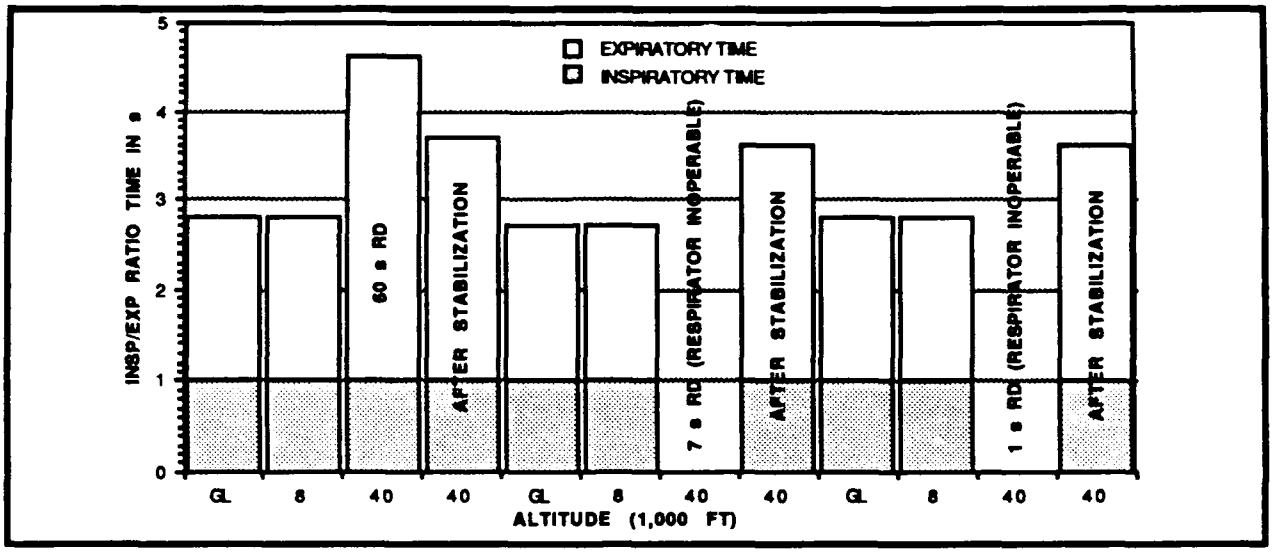

Figure 11. TXP inspiratory:expiratory ratio during rapid decompression testing.

Airborne Feasibility

The respirator operated satisfactorily and was "user friendly." The respirator was very easy to load, secure on board, and off load. However, just as we observed in the hypobaric chamber tests, the respirator required adjustment to compensate for changes in altitude.

Composite Oxygen Cylinder

The DOT-E-8162 seventh revision authorized use of the model ALT-281 for aircraft medical oxygen on 21 Mar 90 (Appendix B), providing regulators used with the cylinders are equipped with a fusible safety relief valve.

Observations

As mentioned earlier, the respirator is an acute-care respirator with no alarms to signal its failure. Therefore, we would like to reiterate the importance of the requirement to have a constant one-on-one clinical relationship. Emphasis is placed on the adjustment of the respirator and the oxygen source pressure to compensate for the changes in altitude. In spite of these drawbacks, the respirator (with the oxygen cylinder) being lightweight, portable, and operable without an additional power supply is a valuable medical instrument; especially in rugged terrain under less than optimal medical conditions. Using the respirator is also preferable to the use of a self-inflating resuscitation bag, since the respirator will deliver a constant ventilation rate and tidal volume. In addition, the PEEP valve accessory will maintain a positive end-expiratory pressure.

CONCLUSIONS

The Military Transporter Respirator, Model TXP, is acceptable for in-flight use, provided the following requirements are met: To adjust to changing altitudes, manual adjustment of the respirator and oxygen source pressure must be made, at least when reaching cruise altitude, and again when descended to ground level. Continuous medical surveillance must be provided by dedicating at least one medical care-provider to monitor the patient . The SCI composite oxygen cylinder is acceptable provided the fusible safety relief device is installed.

ACKNOWLEDGMENTS

We wish to thank the following individuals for their support during the evaluation of the Military Transporter Respirator Model TXP: LtCol Mark G. Swedenburg, Maj Garye D. Jensen, Capt Susan K. Nagel, 1Lt Rebecca B. Schultz, MSgt Ernest G. Roy, MSgt Victor Elizondo, MSgt Gary D. Jenkins, and TSgt Robert J. Van Oss.

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APPENDIX A

SPECIFICATIONS AND OPERATING FEATURES OF THE MILITARY TRANSPORTER RESPIRATOR, MODEL TXP, AND THE COMPOSITE OXYGEN CYLINDER ALT-281-1554

Military Transporter Respirator Model TXP

Part Number: F00013
Serial Number: 0026
Manufacturer and Address: Bird Space Technology
Bird Airlodge
P.O. Box 817
Sand Point, ID 83864

1. The respirator will operate in any position. Its operating ranges are:
Rate: 6 to 375 cycles/min (adjusted by a single ventilation control knob)
I/E ratio: 1:1 through 1:5
Volume: 10 to 1,500 cm^3
Delivery Pressure: 5 to 100 cmH_2O (determined by operational source gas pressure)

2. Safety features:
a. Entrainment port is always directly vented to ambient air. This feature allows the patient access to ambient air.

b. Manual push-buttons for unlimited selection of both inspiratory (dependent on selected regulated operational pressure) and expiratory (no flow).

c. Automatically prevents intrapulmonary breath stacking by automatically adjusting expiratory time with an increase in inspiratory time.

d. Breathing head is separate from phasitron; allowing decontamination using sodium hypochlorite or vinegar.

e. Respirator can be cold ethylene oxide sterilized.

4. The respirator is cylindrical ,and made of transparent polycarbonate plastic which has a high shock rating. Physical dimensions are:
Weight: 0.68 kg (1.5 lb)
Diameter: 10.2 cm (4.0 in.)
Length: 16.5 cm (6.5 in)
Accessory Kit Weight: 0.82 kg (1.8 lb)

Accessories available:
Humidifier (wet wick or aerosol)
PEEP Valve
Aspirator
Needle/Trocar/Bronchoscope

Closed circuit military/mass casualty breathing circuit

Composite Oxygen Cylinder ALT-281-1554

Manufacturer and Address: Structural Composites Industries
325 Enterprise Place
Pomona, CA 91768

Part Number: PN 1270152-3

DOT Designation: DOT-E-8162-1850

Specifications:

Volume: 2,540 cm^3 (1,000 in^3)
Operating Pressure: 1,800 psi
Empty Weight: 5.45 kg (12.0 lb)
Full Weight: 9.32 kg (20.5 lb)

APPENDIX B

U. S. DEPARTMENT OF TRANSPORTATION DOT-E 8162 (SEVENTH REVISION)

U.S Department
of Transportation

Research and
Special Programs
Administration

DOT-E 8162
(SEVENTH REVISION)

MAR 21 1990

1. Structural Composites Industries, Incorporated (SCI), Pomona, California, is hereby granted an exemption from certain provisions of this Department's Hazardous Materials Regulations to manufacture, mark, and sell non-DOT specification cylinders described in paragraph 7 below for use in the transportation of the nonflammable compressed gases described in paragraph 3 below in commerce subject to the limitation and special requirements specified herein. This exemption authorizes the use of a non-DOT specification cylinder for use as an equipment component aboard aircraft and marine craft, and provides no relief from any regulation other than specifically stated.

2. BASIS. This exemption is based on SCI's petition dated September 29, 1989, submitted in accordance with 49 CFR 107.103 and 107.105, and the public proceeding thereon.

3. HAZARDOUS MATERIALS (Descriptor and Class). Compressed air, Carbon dioxide, Halon 1301, Helium, Oxygen, Nitrogen, Argon and mixtures thereof, classed as nonflammable gases.

4. PROPER SHIPPING NAME (49 CFR 172.101). Monobromotrifluoromethane; Air, compressed; Carbon dioxide, liquefied; Nitrogen; Oxygen; Helium; Argon; or Compressed gas, n.o.s., as appropriate.

5. REGULATION AFFECTED. 49 CFR 173.302(a)(1) and 173.304(a)(1), 175.3.

6. MODES OF TRANSPORTATION AUTHORIZED. Motor vehicle, rail freight, cargo vessel, passenger-carrying aircraft, cargo-aircraft only.

7. SAFETY CONTROL MEASURES. Packaging prescribed is a non-DOT specification fiber reinforced plastic (FRP) full composite (FC) cylinder in full compliance with SCI Report 76188 on file with the Office of Hazardous Materials Transportation (OHMT) and with DOT FRP-1 Standard dated March 15, 1982 Revision 1 (178.AA) except as follows:

178.AA-2 Type, size, and service pressure. Type 3FC cylinder consisting of resin impregnated continuous filament windings in both longitudinal and circumferential directions over a seamless aluminum liner; not over 200 pounds water capacity; and service pressure at least 900 psig but not greater than 5,000 psig.

178.AA-5 Authorized material and identification of material.

a. Aluminum liner must be 6061 alloy and T6 temper.

b. Filament material must be Kevlar 49 in compliance with proposed aerospace materials specification (AMS) 3901. Filament must be tested in accordance with ASTM D 2343-67 for strand strength, and ASTM D 3317-74 for Denier.

(1) Strand strength must be 450,000 psig minimum.

(2) Denier must be at least 90 percent of the nominal value specified in AMS 3901. Denier of roving may be certified by the filament manufacturer.

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178.AA-10 Pressure relief devices and protection for valves, relief devices, and other connections.

(a) Pressure relief devices and protection for valves and other connections must be in compliance with 49 CFR 173.34(d), 173.301(g), and 178.AA-18(g)of this exemption. However, only 178.AA-18(g) may be used as the measure of relief device adequacy.

* * * * *

(a) thru (c) * * *

(d) Burst test.

(1) Burst pressure shall be at least 3 times the service pressure and in no case less than the value necessary to meet the stress criteria of 178.AA-7(b). Failure must initiate in the cylinder sidewall. Cylinders with marked service pressure not exceeding 2200 psi containing liquefied gas must remain in one piece. Actual burst pressure must be recorded.

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178.AA-18 Design qualification tests.

(a) thru (d) * * *

(e) * * *

(1) * * *

(2) Burst pressure must be at least 3 times the service pressure and in no case less than the value necessary to meet the stress criteria of 178.AA-7(b). Failure must initiate in the sidewall. Cylinders with marked service pressure not exceeding 2200 psi containing liquefied gas must remain in one piece. Actual burst pressure must be recorded.

(f) Gunfire test. One representative cylinder charged with air or nitrogen to service pressure shall be impacted by a 0.30 caliber armor piercing projectile having a velocity of approximately 2800 feet per second. Cylinders shall be so positioned that projectile impact point is in the bottom cylinder wall aimed to exit at cylinder sidewall, or impact point is on the cylinder sidewall at a 90° angle to the cylinder sidewall axis. Distance from firing location to test cylinder not to exceed 50 yards. Tested cylinder shall reveal no evidence of fragmentation failure. Any tear beyond 3 inches from the entrance or exit hole is cause for rejection. Approximate size of entrance and exit openings must be recorded.

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8. SPECIAL PROVISIONS.

a. Shippers may use the packaging covered by this exemption pursuant to 49 CFR 173.22a.

b. Cylinder service life may not exceed 15 years.

c. Cylinders are authorized only for use as equipment components aboard aircraft or marine craft specifically identified to the OHMT.

d. Cylinder must be packaged in accordance with Section 173.301(k).

e. Each cylinder must be reinspected and hydrostatically retested every three years in accordance with 49 CFR 173.34(e) as prescribed for DOT 3HT cylinders, except that the rejection elastic expansion criterion does not apply, and permanent volumetric expansion must not exceed 5 percent of total volumetric expansion at test pressure. Retest dates must be steel stamped on the outer exposed metallic surface of the cylinder neck, or marked on a label securely affixed to the cylinder and overcoated with epoxy. Reheat treatment or repair of rejected cylinders not authorized.

f. A copy of this exemption must be carried aboard each cargo vessel and aircraft used to transport packages covered by this exemption.

g. Cylinders subjected to action of fire may not be placed in service.

h. Cylinders used in oxygen service must be in compliance with 49 CFR 173.302(a)(5)(i) thru (a)(5)(iv).

i. A copy of this exemption, in its current status, must be maintained at each manufacturing facility at which this packaging is manufactured and must be made available to a DOT representative upon request.

9. REPORTING REQUIREMENTS. Any incident involving loss of contents of the package or packaging failure must be reported to the OHMT as soon as practicable.

10. EXPIRATION DATE. October 31, 1991.

Issued at Washington, D.C.:

MAR 2 1 1990

Alan I. Roberts (DATE)
Director
Office of Hazardous Materials
Transportation

Address all inquiries to: Director, Office of Hazardous Materials Transportation, Research and Special Programs Administration, U.S. Department of Transportation, Washington, D.C., 20590. Attention: Exemptions Branch.

Dist: USCG, FAA, FHWA, FRA.